Summary of Electronics Meeting // 16th October 2019

Team Attendees: Liam Field, Teresa Bompczyk, Sean Flynn

Beacon

ANGEL Beacon operates at 406MHz and emits 121.5MHz homing signal. Need to *implement VHF receiver onboard* to pick up 121.5MHz signal. Current thoughts are to find a coiled antenna that can pick up this signal and configure two of these perpendicular to each other, or find a parabolic amplifier (reflects signal to a point x a certain perpendicular distance d from central point of amplifier). Less safe solution: slowly rotating antenna parallel to horizontal axis of water surface plane, will output direction of the strongest signal. *Need software integration!* But first, have to determine the type of receiver being used and the math needed to output a correct directional vector.

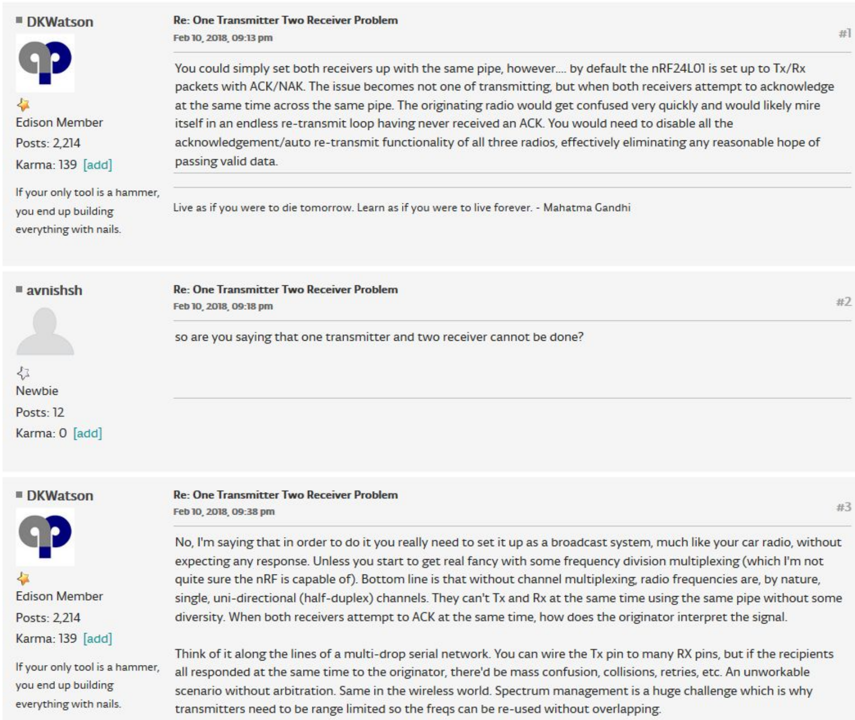
Main Idea: receiver antenna in horizontal plane, when turning will pick up signal strength. Find maximum strength and yield directional vector. Below is a receiver that will pick up the 121.5MHz signal and output a voltage based on the strength of the signal. Threshold for this voltage will be needed for calibration of software… some mathy stuff needed here to magically turn this into direction vector so that it can be implemented to the motor, jet pump, etc.

*__Antenna Specifications__

- Application: Airborne ELT
- Frequency: 121.5 & 406 MHz
- Impedance: 50 ohms nominal
- VSWR: 2.0:1 Max at 121.5 MHz 1.5:1 Max. at 406 MHz
- Polarization: Vertical
- Pattern: Omni-Directional
- Connector: BNC Female
- Max Weight: 3 ounces
- Max Height: 24 inches
- RF Power Capacity: 10 watts CW

*Need accuracy of Rasp. Pi's internal clock (imbedded antennae design yields scale of nanoseconds). *Any research on this would be helpful*. For the directional position needed, distance between receivers is indirectly proportional to the clock accuracy needed; a greater distance between two antennae yields less clock accuracy needed.

Antenna receives VSWR: 2.0:1 Max at 121.5 MHz 1.5:1 Max. at 406 MHz, utilize notch filter within range of error for signal identification. Separate piece of code needed for outputting directional vector, *dependent entirely on receiver setup*. Clock accuracy of Rasp. Pi will determine precision of triangulation (detection of signal), as our two receivers will likely be a small distance apart. Issue of one signal coming in and two receivers need to be read *at the same time*. This would give a more precise triangulation of beacon location. Small errors in clock accuracy may heavily influence location detection, especially for close ranges. Forum OP using Arduino. (Click picture below to link forum site):



DKWatson
Edison Member
Posts: 2,214
Karma: 139 [add]
If your only tool is a hammer, you end up building everything with nails.

Re: One Transmitter Two Receiver Problem
Feb 10, 2018, 09:13 pm #1

You could simply set both receivers up with the same pipe, however.... by default the nRF24L01 is set up to Tx/Rx packets with ACK/NAK. The issue becomes not one of transmitting, but when both receivers attempt to acknowledge at the same time across the same pipe. The originating radio would get confused very quickly and would likely mire itself in an endless re-transmit loop having never received an ACK. You would need to disable all the acknowledgement/auto re-transmit functionality of all three radios, effectively eliminating any reasonable hope of passing valid data.

Live as if you were to die tomorrow. Learn as if you were to live forever. - Mahatma Gandhi

avnishsh
Newbie
Posts: 12
Karma: 0 [add]

Re: One Transmitter Two Receiver Problem
Feb 10, 2018, 09:18 pm #2

so are you saying that one transmitter and two receiver cannot be done?

DKWatson
Edison Member
Posts: 2,214
Karma: 139 [add]
If your only tool is a hammer, you end up building everything with nails.

Re: One Transmitter Two Receiver Problem
Feb 10, 2018, 09:38 pm #3

No, I'm saying that in order to do it you really need to set it up as a broadcast system, much like your car radio, without expecting any response. Unless you start to get real fancy with some frequency division multiplexing (which I'm not quite sure the nRF is capable of). Bottom line is that without channel multiplexing, radio frequencies are, by nature, single, uni-directional (half-duplex) channels. They can't Tx and Rx at the same time using the same pipe without some diversity. When both receivers attempt to ACK at the same time, how does the originator interpret the signal.

Think of it along the lines of a multi-drop serial network. You can wire the Tx pin to many RX pins, but if the recipients all responded at the same time to the originator, there'd be mass confusion, collisions, retries, etc. An unworkable scenario without arbitration. Same in the wireless world. Spectrum management is a huge challenge which is why transmitters need to be range limited so the freqs can be re-used without overlapping.

<u>Motor</u>

To be implemented with FishPi software. *Need structural specifications.*

Motor Specifications

- Product Dimensions 6.1 x 4.5 x 2.2 inches
- Item Weight 10.2 ounces
- Shipping Weight 10.2 ounces
- ASIN B01L4C6HWC
- Item model number KXSS0501

Amazon description: "Key Features 4-Pole design for increased torque and improved overall efficiency Sensorless brushless technology for improved performance and maintenance free operation Standard 1/8 in shaft 3.5mm bullet style connectors 4000Kv motor included Waterproof ESC Pre-wired with high-current EC3 connector and 3.5mm bullet style connectors NiMH and Li-Po compatible 70A can handle 49 cell NiMH or 2S3S LiPo Built in Cooling fan Easily programmable through integrated setup button Compact design for easy fit into most any 1/10th scale on and off road platform Overview The Kinexsis brushless systems offer price sensitive enthusiasts the ultimate solution when searching for an easy and affordable method of stepping up to brushless power. Designed for most 1/10th scale on and off road electric vehicles, each system comes with everything users need to upgrade to brushless power. All systems include a potent 4-pole sensorless brushless motor and 70A waterproof ESC that comes pre-wired with a high-current EC3 connector. The ESC is Ni-MH and Li-Po/Li-Fe compatible and was designed to handle up to a 9 cell Ni-MH pack or 3S Li-Po/Li-Fe. Kinexsis brushless systems are compatible with most 1/10th scale on and offroad electric vehicles including 1/10th scale ECX, Losi, HPI, Traxxas, Associated and many more. Type: Brushless, sensorless inrunner motor/70A waterproof ESC combo Number of Poles: 4 Size: 3650 Bearings or Bushings: Two 5 × 13 × 4mm Bearings Adjustable Timing: No RPM/Volt (Kv): 4000Kv Idle Current (Io): 1.5 ± 0.5 @ 7.2V Output: 290W Efficiency: 90% Shaft Diameter: 1/8 in Shaft Length: 15mm Forward: Yes Reverse: Yes Brakes: Yes Auto C"

Email sent to grad students:

To: bbezanson@gmail.com [Brian], grantira@buffalo.edu [Grant]
From: tbompczy@buffalo.edu

Good evening,

Vlad T. (cc'd on this email) referred you as a knowledgeable grad student who might be able to provide some advice for UB's Micro-g Team. We're working on SAVER, an autonomous vehicle capable of locating and responding to an emergency beacon signal in a maritime environment. The transmitting device is an ANGEL beacon, which operates at 406MHz (long-range to alert emergency services) with a 121.5MHz homing signal (for close-range detection).

Our design team has come to an impasse with regards to the implementation of a receiving device which is able to read the 121.5MHz signal in accordance with our design constraints. We've come across this commercially available antenna, but need to output either a directional vector pointing toward the ANGEL beacon or the latter's GPS coordinates. Preliminary ideas include:

1) find a commercially available coiled antennae (antennas? English is hard, man) that can pick up this signal and configure two of these perpendicular to each other (unable to find product as of yet);
2) a parabolic amplifier with stationary receiver (reflects signal to a point *x* [location of receiver] a certain perpendicular distance *d* from central point of amplifier);
3) less safe solution: slowly rotating straight antenna parallel to horizontal axis of water surface plane, will output direction of the strongest signal;
4) probably won't give level of precision needed within design constraints: two vertically-oriented omnidirectional antennae, either both placed on UAV or one on UAV and one deployed in separate floating buoy (super unsafe).

All of these rely on some sort of triangulation for determining the location, but do you have an opinion of what might work best for this challenge (rough structure dimension: < 4ft x 2ft) keeping safety/waterproofing in mind? *More important question*: how to go about triangulation calculations within time clock constraints of a Raspberry Pi? Based on some rough estimates, we figured that two antennae placed on the UAV ~0.5ft apart would be in the order of nanoseconds. Do you happen to know if a Raspberry Pi would be able to give precise readings of this order?

My apologies if anything is unclear, not many of us have a background in this area... it's been a challenge to get even this far with the signalling portion of the project! We understand your schedules are demanding, so no worries if you cannot find time to reply. Any and all advice would be greatly appreciated, and feel free to reach out if you need clarification of specific aspects of the project. I've attached the NASA challenge document (we are working on the very first challenge, SAVER) for reference. Looking forward to your reply, and thank you in advance!

Best regards,
AIAA Micro-g Team

Vladimir :Technique two seems most viable

RESPONSE:
To: tbompczy@buffalo.edu
From: bbezanson@gmail.com [Brian]

There are two general approaches for radio direction finding, which I think you've already got the general idea of: (1) use a directional antenna and watch the signal strength while you sweep the antenna around, or (2) use multiple antennas and measure the differences in when the signal arrives at each antenna.

Technique (1) is very simple for manual operation, but tends not to be very precise for frequencies as low as 121.5 MHz because highly directional antennas would have to be huge. The sort of antenna you can make easily portable doesn't have a very sharp peak of sensitivity, so you get rough "over [hand waves] there-ish" indications of direction. Parabolic reflectors would be impractically large, so you generally see two- or three-element Yagi antennas used for VHF frequencies.

When working with strong signals or short ranges, it's also possible to use an antenna which has a sharp null (a direction in which the antenna is deaf), and hunt for the antenna orientation that produces minimum signal. The null is usually forward-backward symmetric, which creates ambiguity if you don't already know if the transmitter is in front of you or behind you.

Technique (2) is much more amenable to automatic operation and can be accomplished with simpler equipment than you might expect. Rather than trying to make absolute time measurements with a computer's clock, you connect multiple antennas to a single receiver through a multi-pole switch and rapidly switch between the antennas. Switching from one antenna to another causes the phase of the signal coming in to the receiver to jump forward or backward. A forward jump means the newly connected antenna is closer to the transmitter than the previous antenna; a backward jump means it's further away.

An ordinary FM receiver is already designed to translate variations in the phase of a radio signal to a low-frequency voltage output, or modern systems may use a software-defined receiver. Correlating the detected phase jumps to the signals controlling the antenna switch lets you determine direction. A pair of antennas provides a left/right indication but has forward/backward ambiguity. A three-antenna array resolves that ambiguity. A four-antenna array improves angular resolution a bit and can actually make the circuitry simpler than three; as far as I know this is the most common configuration. The antennas have to be

spaced less than 1/2 wavelength apart from each other, or ambiguities appear again.

I don't know how much of this you want to tackle yourselves vs. buying something that already does it. Look up "pseudo-Doppler" (or sometimes just "Doppler") radio direction finding equipment. You might also want to know the term "fox hunt," which is what amateur radio geeks call the practice of hiding and finding transmitters for fun -- they come up with lots of low-budget, often janky and terrible, but creative solutions to this kind of problem. Be warned that anything involving a software-defined radio will probably involve a much larger amount of software effort than radio effort.

Other Antennae Options:

https://www.ebay.com/itm/312657730677
- 118-135 MHz range, $7.12

Power

Max power is 300 W (12 V and 25 A).